

博士論文（要約）

**Sodium and potassium intake assessed by two 24-hour urine
collections and related dietary patterns among Indonesian people:
A nutritional epidemiological study**

（インドネシア人における 2 回の 24 時間畜尿を用いたナトリウ
ム・カリウム摂取量の評価および食事パターンとの関連：
栄養疫学調査）

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Introduction:

Non-communicable diseases (NCDs) are leading causes of mortality worldwide. Almost three-quarters of all NCD-caused deaths occur in low- and middle-income countries, such as Indonesia. The leading causes of death in Indonesia are stroke, cardiovascular disease (CVD), and cancer. In stroke and CVD, the main causative factor is hypertension. Therefore, strategies to reduce hypertension are critical to NCDs and complications' prevention and reduction.

The World Health Organisation (WHO) reported that unhealthy diet contributes to around 30% of preventable morbidity and mortality due to NCDs, particularly from hypertension. According to the WHO and other studies, the most cost-effective means of reducing hypertension is a salt reduction programme. The WHO recommended exploring and evaluating salt consumption by country, with precise subgroup sample size (i.e., age, sex, area) using a "gold standard" measurement per country. However, no nationwide survey of Na and K intakes in the Indonesian population exists. Hitherto, only two studies have evaluated Na and K intakes among Indonesian; hence, both had methodological limitations on Na and K intakes.

Further, dietary sources of Na/K vary widely across populations and cultures. To implement a successful salt reduction programme, a study to explore the variety of Na and K contents of Indonesian food is needed. The WHO recommended that studies should be based on groups of foods (dietary patterns) for a better understanding of the dietary recommendations for a wide population. Grouping of foods into a dietary pattern can reflect the actual food consumption and show associated dietary patterns of higher Na and K intake. Therefore, the overall aims of the present study were to evaluate Na and K intakes and their association with dietary patterns among people in a city of Indonesia.

Methods:

This was a cross-sectional descriptive correlational study from November 2018 to September 2019. This study was conducted in a city of East Java, Indonesia. Nganjuk City, a projection of the sub-urban area, has a flat land and is a non-coastal city. Data collection for this survey was by home visit, by a single main investigator. The participants were community-dwelling people in Nganjuk City who met the eligibility criteria. We included the young (aged 20-59 years) and older adult (aged ≥ 60 years) populations. Sample selection was by the random sampling method based on the city office data using a computer random number generator based on the residents' ID card numbers. The census data that was used in this study was reliable. The research team calculated the sample size based on the overview of the WHO/Pan American Health Organisation (PAHO) study population of Na levels.

The author collected data about participants' characteristics, physical examination, environment, salt threshold sensitivity test (STST), 24-h urine collection, and dietary behaviour. For participants' characteristics; 1) the WHO STEPS instrument guideline was used to collect personal data, 2) activities of daily living was measured using the Barthel Index, 3) cognitive status was measured using the Mini-Cog[®], 4) activity patterns were measured using the physical activity level from the International Physical Activity Questionnaire (IPAQ), 5) living status. For physical examination, blood pressure, body weight, and height were measured. About the environment, the author collected temperature and humidity once daily at 10:00 a.m. in the community area. Further, for the STST, the author conducted based on protocol of Kirsten and Wagner (2014).

The author estimated daily Na/K intake from urinary excretion of Na and K. The 24-h urine collection was performed in two consecutive days. The 24-h urine collection was conducted using a protocol based on the WHO/PAHO report (2010) and a previous study conducted in Japan. The collection start and finish times were set up by the author to make the timings of collection easier for participants to remember. The author also provided self-recorded sheet, for the participants to record the start and finish times, as well as the estimated frequency and volume of urine that they forgot or failed to collect. We included the estimated amount along with the actual volume of urine collected. The overall total amount of urine, Na/K urine excretion, and Cr urine were calculated by Prodia Medical Laboratory.

Dietary behaviour during the past month was assessed using the Food Frequency Questionnaire (FFQ). FFQ is based on the population food reference in Jakarta (Capital city of Indonesia), where I expected a close dietary behaviour to that of my study population. There are 125 total food items were included in this study. Participants were asked how often they consumed the foods over the previous month. The frequencies were categorised as never, 1-6 times/d, 1-6 times/week, and 1-3 times/month. For the analysis, the author grouped the FFQ food items into 22 groups based on the nutrient profile, the process of cooking, and culinary usage among the foods.

In statistical analysis, the urine sample was confirmed completeness of the 24-h urine collection before analysis using 2 definitions. Day 1 used Joossens et al.'s equations and day 2 used the equations based on the urine volume and self-reported urine collection. The creatinine level is a better indicator to evaluate the completeness of 24-h urine; however, creatinine value was not available for day-2 urine collection. For urinalysis, the author conducted two types of urinalysis. First, urinalysis was categorised by sex using successful urine samples from day 1 or 2, or both, collections. Second, the distribution of the habitual Na and K excretions was calculated

only for participants with 2 successful 24-h urine collections.

Furthermore, the diet and urine excretion of Na and K were analysed for men and women separately using factor analysis. Before including the food consumption value into factor analysis, the author made an adjustment for energy intake. The selection of the number of factors was based on the latent root criteria, with eigenvalues over 1.5, the scree plot test, and the interpretability of the combination of food groups on the factors. The orthogonal transformation (Varimax rotation) was used to achieve a simpler structure. The factor score for each dietary pattern was categorised into quantiles (Q1 to Q4). Then, multivariate-adjusted means of Na and K excretions and Na:K ratio in each quantile were calculated by adjusting for age (Model 1). The author further adjusted for education, smoking, and PAL in Model 2. Trends of association in factor score quantiles of dietary patterns with urine excretions were assessed by the linear regression model.

Results:

This study recruited 528 people, with 22 excluded (response rate: 98.1%). Of 506 participants who completed the questionnaire and obtained other measurements, 22 failed to collect the urine sample. Therefore, only 484 participants had 24-h urine collection. The average age of participants was 56.5 years. The prevalence of hypertension was 52.5% and 23.8% among older adults and young people, respectively.

Mean Na and K excretions overall was 101.5 mmol/d (range 17-265) and 24.2 mmol/d (range 7-69), respectively. The results of multivariate linear regression analysis of age, BMI, and physical activity with urine excretions showed that younger age was significantly associated with higher Na excretion in women, but not in men. For both sexes, higher BMI was significantly associated with higher Na excretion. In both sexes, higher BMI and higher physical activity was associated with higher K excretions. However, significant association with increased K excretion among older participants was shown only in men. Younger people and those with lower physical activity had higher Na:K ratio among men. The Na:K ratio was significantly higher in those with higher BMI and higher physical activity levels. For the habitual intake, none of the K intakes met the recommendation value in both sexes. Concerning Na intake, 20% of all participants met the recommendation of the WHO.

The 22 food groups were entered into the factor analysis. In a factor analysis by sex, four factors resulted. Factors were labelled based on the factor loadings > 0.4 . The percentage of the total cumulated variance was 38.5% (men) and 40.7% (women). In men, the patterns were M1 'Meat, vegetable, oil (snack), desert, and fruit', M2 'Staples, oil (soybean), and coffee/tea', M3 'Noodle, oil (staples and root) and salty sea', M4 'Vegetable, non-oil (soybean), and milk'. For

women, the patterns labelled W1‘Meat, vegetable, and fruit’, W2‘Staples, oil (root and soybean), desert, and coffee/tea’, W3‘Noodle, oil (processed meat and snack), and salty sea’, W4‘Composite, non-oil (soybean and snack)’.

In the multivariate-adjusted means for Na and K excretions and Na:K ratio throughout the quantiles of all the dietary patterns. In men, after controlling for confounding factors, higher factor scores for M1‘Meat, vegetable, oil (snack), desert and fruit’ pattern were positively associated with higher Na and K excretions (P trend < 0.024 and < 0.036, respectively). The M2‘Staples, oil (soybean), and coffee/tea’ pattern was negatively associated with lower Na and K excretions (P trend < 0.040 and < 0.0036, respectively). M3‘Noodle, oil (staples and root) and salty sea’ pattern was positively associated with higher Na and K excretions (P trend < 0.023 and < 0.001, respectively). The M4‘Vegetable, non-oil (soybean), and milk’ pattern was negatively associated with lower Na excretion and Na:K ratio (P trend < 0.001 and < 0.026, respectively).

For women, higher factor scores for W1‘Meat, vegetable, and fruit’ pattern were negatively associated with lower Na:K ratio (P trend < 0.012). The W2‘Staples, oil (root and soybean), desert, and coffee/tea’ pattern was negatively associated with lower K excretion (P trend < 0.046). The W3‘Noodle, oil (processed meat and snack), and salty sea’ pattern was positively associated with higher Na excretion and higher Na:K ratio (P trend < 0.001 and 0.002, respectively). The W4‘Composite, non-oil (soybean and snack)’ pattern was not associated with Na and K excretions and Na:K ratio.

Conclusion:

Mean salt intake among the participants was estimated to be 5.9 g/day (6 g/day in men and 5.9 g/day in women). This finding is higher than the WHO recommended values for Na excretion, <73.1 mmol/d (5 g NaCl). Among 380 participants, the Na intake of 72 (20%) met the WHO recommended value. For K intake, no participant (0%) met the WHO recommended value. In participants of both sexes, the highest Na intake was associated with the higher quantile of M3‘Noodle, oil (staples and root) and salty sea’ and W3‘Noodle, oil (processed meat and snack). The M1‘Meat, vegetable, oil (snack), desert and fruit’ and W3‘Noodle, oil (processed meat and snack), and salty sea’ patterns contributed to the highest K intake. In conclusion, Na intake was excessive while K intake was inadequate compared to the values recommended by the WHO. These results suggest a need to develop a customized programme to reduce salt intake in this study area.